Coober Pedy Hybrid Renewable Project

Second Year Performance Report

1 July 2018 to 30 June 2019

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1	NA	Minor amendments	TGL	VL	GE	8/10/2019
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Table of contents

Appendices

1. EXECUTIVE SUMMARY

Energy Generation Pty Ltd (EnGen), a wholly owned subsidiary of Energy Developments Pty Limited (EDL), is the owner and operator of the Coober Pedy Hybrid Renewable Project (Project). The Project commenced commercial operations on 1 July 2017 and is the exclusive supplier of power to the town of Coober Pedy in South Australia.

This is a significant project for EDL as well as local, state and federal governments and the renewable energy industry. Over FY2019, the Project has achieved average renewable energy penetration of 75.6%. This compares with the FY18 performance for the nine months post-settling period from Oct 2017 of 70.7%.

EDL considers this to be world-leading performance for a megawatt-scale remote energy hybrid power project. Importantly, this level of performance has been achieved without adversely impacting power quality or reliability. Unplanned outages remained at a reduced level in FY2019 compared to the pre-hybrid outage rate.

This report provides an overview of the performance of the Project during its second year of commercial operations.

2. INTRODUCTION

2.1 Background

Electricity demand in Coober Pedy averages 1.4MW and reached as high as 3.1MW in 2011.

EDL owned and operated the existing Coober Pedy diesel-fired power station that supplied 100% of the town's electricity.

In 2013, EDL began investigating the potential to integrate renewable energy into the existing power station to reduce diesel consumption in Coober Pedy. EDL submitted an Expression of Interest to the Australian Renewable Energy Agency (ARENA) IRAR program in November 2013, which ultimately led to the execution of a funding agreement with ARENA in July 2014.

Construction of the Project commenced in September 2016 and commercial operations commenced on 1 July 2017. The Project has now completed its second year of operation.

The completed project configuration comprises:

- two 2.05MW Senvion MM92 wind turbines
- 1MW solar (First Solar 107.5Wp Series 4TM, with SMA SC1000XP inverter housed in Sunny Central MVPS)
- 1.5 MW/ 0.49 MWh BESS (Toshiba SCiB)
- two 850kVA Diesel UPS (Hitzinger/Cummins KTA38)
- 3000kW dynamic resistor
- Advanced Hybrid Off-grid Control System
- associated auxiliary and ancillary equipment operating in conjunction with pre-existing diesel-powered power station (eight 518kWe Deutz TBD6 V12)

2.2 ARENA funding agreement

The Project is supported by up to $18.4 million in funding from ARENA (out of a total project cost of $39 million).

As part of the ARENA funding arrangements, EDL shares knowledge gained during the development, construction and operation of the Project.

2.3 Location

Figure 1.1 below provides an overview of the location of the Project and associated infrastructure, including connecting power lines.

The wind turbine location was selected to ensure compliance with Coober Pedy Airport height restrictions, minimise the distance from the power station to reduce transmission losses and capital costs, avoid the sterilisation of opal resources and consider requirements arising from cultural heritage surveys conducted in conjunction with the Traditional Owners.

Figure 1.1: Project site overview

3. YEAR TWO PERFORMANCE

3.1 Overview

During the feasibility stage, the expected performance of the Project was estimated using long term data sets for renewable resources (solar and wind), as well as detailed energy modelling. From this process, it was expected that the Project would achieve, on average, 70% renewable energy penetration over its 20-year life.

The key performance metrics and a comparison with performance to date are shown in Table 3.1 (Coober Pedy renewable energy contribution summary) below. Further details are provided in Section 3.6.

In summary, the Project has improved the overall renewable energy contribution to 75.6% in FY2019, slightly exceeding modelled performance.

The achieved renewable contribution is a function of the match between the load, wind and solar generation and the performance of the enabling technologies. The customer load was marginally below the design assumption (~2.2%). Annual average wind speed at 7.9 m/s was slightly above design estimates of 7.6 m/s at 80 m hub height (~4%). The solar resource was 8% higher than design estimates. Losses have been slightly less than design, primarily due to lower flywheel parasitic energy on the DUPS (diesel un-interruptible power supply) than originally estimated.

Importantly, operation of the Project continued through its second year without any material safety incidents.

Table 3.1: Coober Pedy renewable energy contribution summary

Parameter		Units	Design	Actual		Post-settling Oct 17 to Jun18	
				FY19	FY18	Design	Actual
Load and system performance							
	Customer Load	MWh	11,840	11,563	11,570	8,955	8,725
	Potential Renewable	MWh	16,826	18,444	17,569	12,853	12,605
	Renewable "curtailed/spilled"[1]	MWh	7,138	8,550	8,728	5,525	5,603
	System losses	MWh	1,400	1,150	1,017	1,059	833
	Net RE to customer	MWh	8,288	8,744	7,824	6,269	6,169
	Net RE to customer	%	70.0%	75.6%	67.6%	70.0%	70.7%
	Time at 100% RE (ZDO)	%	>50%	52%	39%	>50%	48%
	Longest continuous period of 100% RE	hrs		81	71.5		
Wind generation							
	Wind speed at 80m hub height	m/s	7.6	7.9	7.6	7.6	7.5
	Potential generation[2]	MWh	14,643	15,939	15,100	11,172	10,744
	Potential capacity factor	%	40.8%	44.4%	42.0%	41.5%	40.0%
Solar PV							
	Solar resource (GHI)	kWh/m^2	2,067	2,252	2,211	1,654	1,765
	Potential generation[3]	MWh	2,183	2,504	2,469	1,681	1,861
	Potential capacity factor ac	%	22.7%	26.0%	25.6%	23.3%	25.8%
BESS							
	Annual discharge	MWh	142	126	117	108	96

The actual net contribution to customer load from each of wind and solar depends on allocation of the 'spill'. Wind is often spilled as it frequently exceeds the load at night, and either solar or wind may be spilled during high renewable generation during the day. During periods of very high excess renewables, the production from wind and/or solar output may also be curtailed by reducing the power set point.

Figures 3.1 to 3.6 compare the modelled and actual RE contributions to customer load for a summer and winter day in FY2018 and FY2019 (with spill allocated to wind first).

[1] During periods of very high excess renewable, the production from wind or solar output may be "curtailed" rather than generated and electricity being "spilled" through the resistor.

[2] "Potential renewable/generation" refers to the theoretical renewable generation available given the ambient climatic conditions, equipment installed and estimated losses. Potential wind generation is calculated using the turbine's power curve with losses applied.. Estimates are as received at the power station HV bus after transmission losses.

[3] "Potential renewable/generation" refers to the theoretical renewable generation available given the ambient climatic conditions, equipment installed and estimated losses. Potential solar generation is calculated using measured irradiance and PVSyst. Estimates are as received at the power station HV bus after transmission losses.

Note this is an average of all days in the respective month and, as such, always shows some residual diesel generation.

However, the Project has run with 100% renewable and zero diesels operating (“ZDO”) for approximately 52% of time in FY19, which compares well with design estimates of around 50%. See Section 3.6.1 for further daily performance data.

Overall the system is performing as expected. The advanced control system and enabling technologies ensure power quality (system frequency and voltage) is maintained, while managing renewable intermittency and maintaining power reliability.

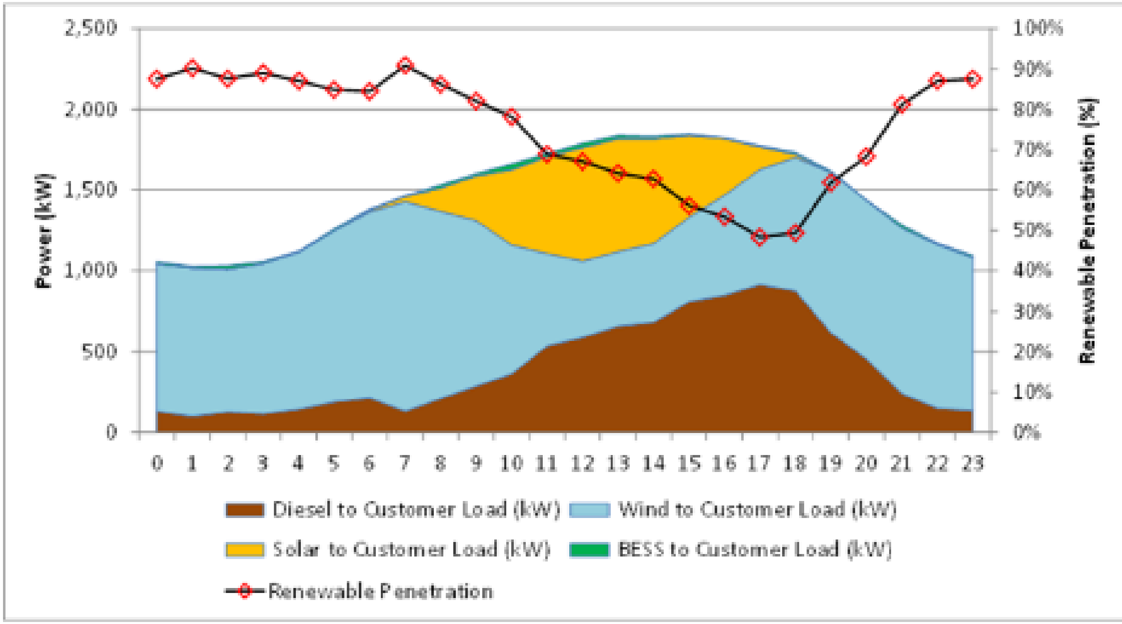

Figure 3.1: Average day in January (design)

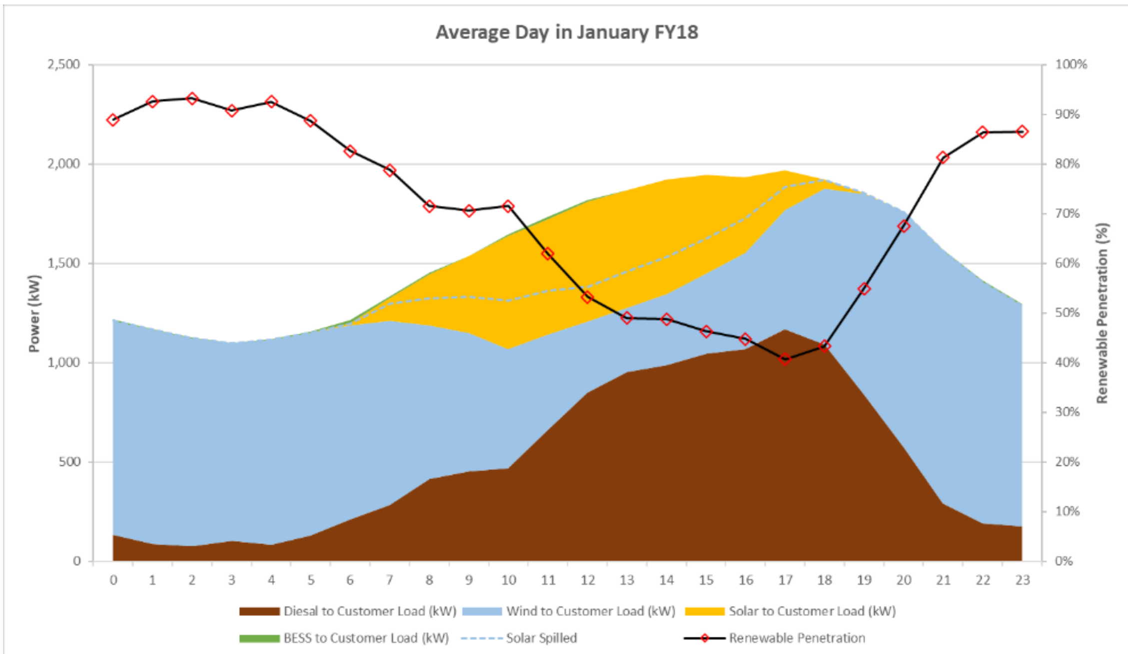

Figure 3.2: Average day in January 2018 (actual)

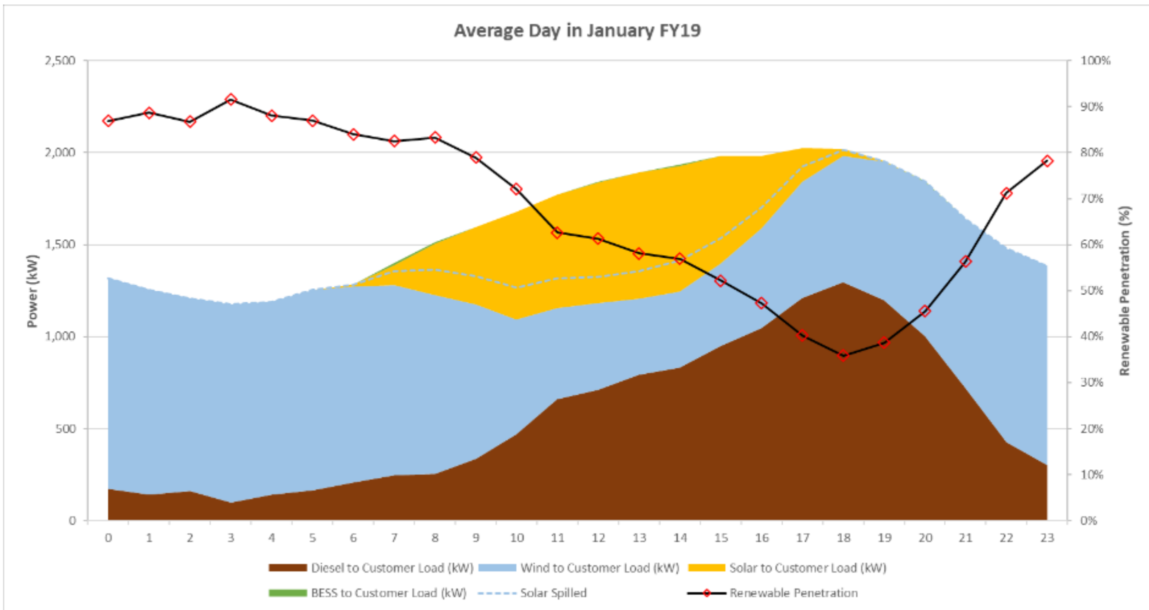

Figure 3.3: Average day in January 2019 (actual)

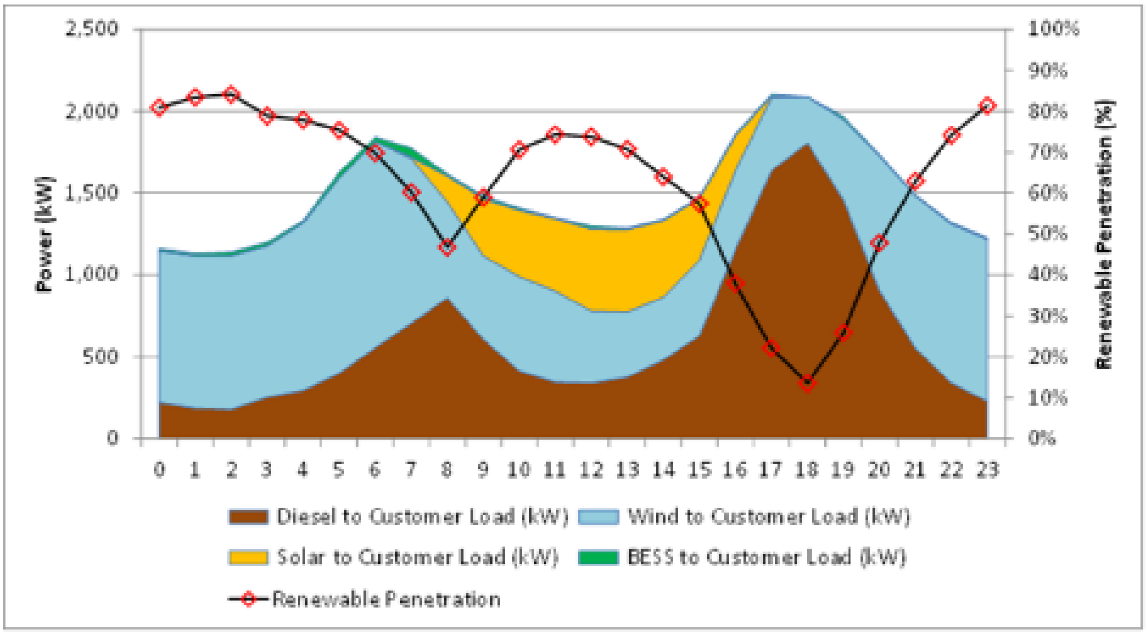

Figure 3.4: Average day in July (design)

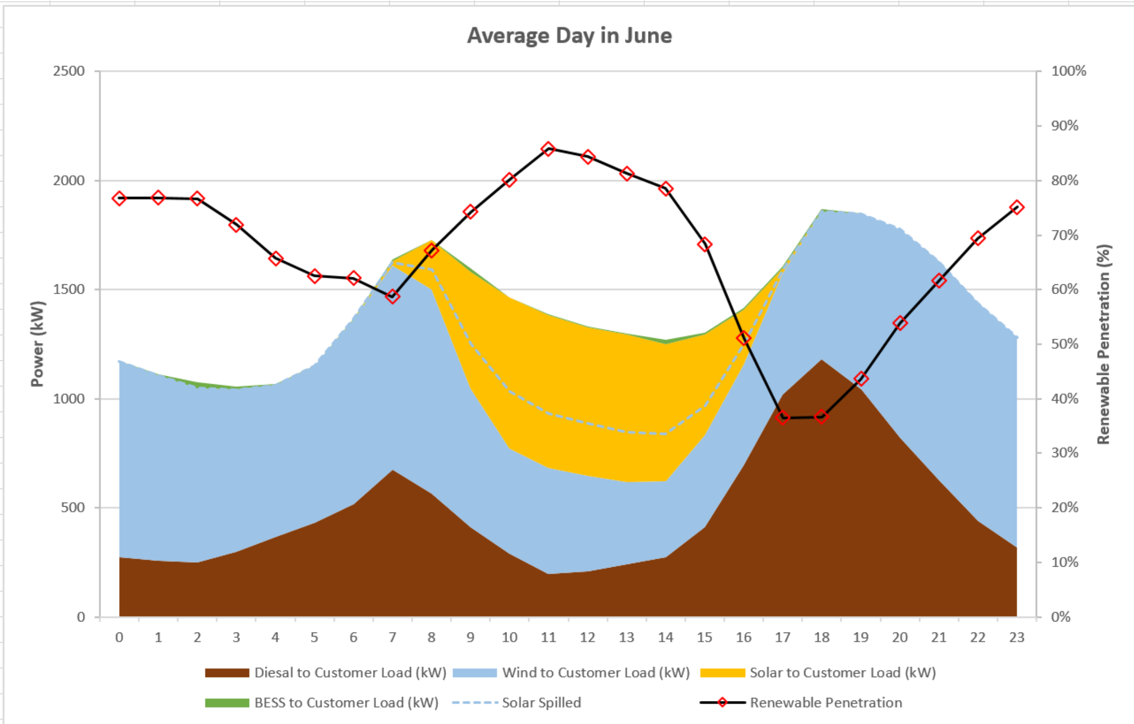

Figure 3.5: Average day in June 2018 (actual)

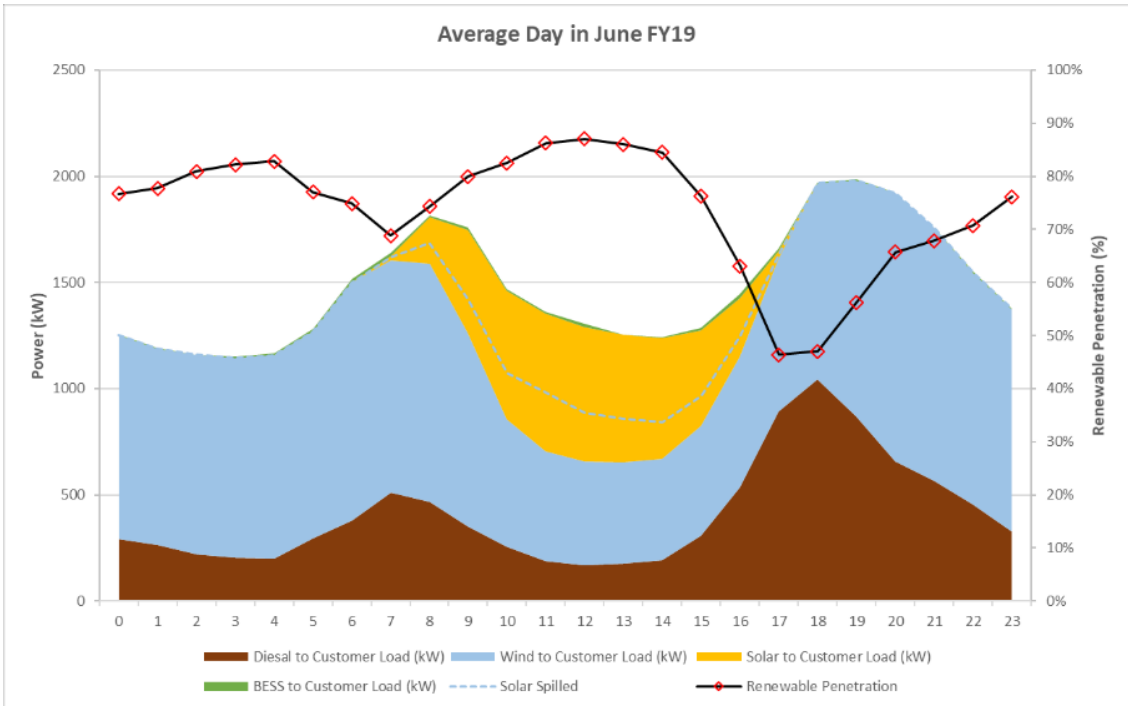

Figure 3.6: Average day in June 2019 (actual)

3.2 Solar

3.2.1 Solar irradiance

During the feasibility study, the solar resource was largely estimated using satellite-based data. There was no site-based monitoring data available, although some output data was obtained from an 80kW Council-owned PV array at the water treatment plant.

Solar irradiance is now measured by three devices alongside the solar array:

- Global Horizontal Irradiance (GHI) Pyranometer - Zipp and Konen CMP 10 integrated into Luft WS510-UMB
- Plane of Array (POA) Pyranometer - Zip and Konen – CMP11
- Plane of Array (POA) Reference Cell – First Solar Calibrated FS3 110 W module (as used in the solar farm) with Atonomics RDE200 Interface

Table 3.2 compares the design and measured solar resources to June 2019.

Solar GHI irradiance in FY 2019 was 8% higher than the expected long-term average, with the biggest uplifts occurring during the winter months.

Table 3.2: Design and measured solar irradiance

Period	Solar Irradiance GHI (kWh/m^2)			Solar Irradiance Global POA (kWh/m^2)				
	Horizontal Pyranometer			**Pyranometer**			**Reference Cell**	
	Design	**FY19[5]**	**FY18**	**Design**	**FY19[5]**	**FY18**	**FY19**	**FY18**
Jul	106	127	122	147	184	178	181	176
Aug	135	146	151	172	190	197	187	195
Sep	172	185	174	200	213	201	209	198
Oct	215	201	225	223	202	228	201	226
Nov	213	229	241	202	210	203	208	204
Dec	241	259	233	219	226	213	224	213
Jan	227	248	247	211	222	222	221	223
Feb	204	233	210	203	227	204	226	206
Mar	194	210	212	217	227	233	229	233
Apr	146	169	159	182	209	196	209	197
May	121	135	131	168	187	183	187	181
Jun	94	111	107	132	163	156	161	154
Total	**2067**	**2252**	**2211**	**2276**	**2460**	**2414**	**2443**	**2404**

[5] Data quality is high with 99.4% availability.

3.2.2 Solar system performance

Solar PV performance ratio (PR) to date continues to exceed design expectations. The expected PR in the first year was 80.2% lowering to 79.6% in year 2 for module degradation[6].

The measured FY19 PR was 82.8% over non-curtailed periods, almost the same as the previous year at 82.6%. The better than expected performance appears primarily due to actual soiling (~ 2%) being less than design soiling (5%).

The solar inverter can follow a setpoint very rapidly. Once curtailed, the output can be regained within seconds and hence provides a rapid response to wind or load changes. Hence, solar generation is preferentially curtailed over wind generation.

Solar output was curtailed for 54% of daytime periods in FY19, more than the 39% in FY18. The performance assessment is limited to non-curtailed periods, which may introduce some bias as non-curtailed periods tend to be in the morning and evening, and in winter months when output and temperatures are lower and the PR typically higher. Hence the 82.8% measured PR maybe an overestimate of uncurtailed annual performance.

Generally, the availability of the solar system has been reasonable and within expectations, except for two inverter stack failures, as described below:

- The first occurred on 26 March 2019 and was corrected on 11 April 2019. The inverter (and associated MVPS kiosk) carries a five-year SMA manufacturer warranty—therefore the repair work was covered under warranty
- The second failure occurred on 8 May 2019 and was corrected by 23 May 2019. The failure mode in the second outage initially appeared to be the same. However, root cause analysis by SMA revealed a separate third party supplied component failure, which had also caused the first failure. SMA replaced the full inverter on warranty and the fault is not expected to reoccur

On both occasions the inverters were out of service for more than two weeks, however, the overall RE% impact was low as wind was often available to fill the gap.

The principal reason for the delay in returning the inverters to service is the remoteness of the location, and the logistics associated with arranging for technical personnel and parts to be shipped to site.

[6] The design PR was 79.5% with 5% soiling and 95% availability. The PVSyst model was updated to reflect the as built system increasing expected yield slightly. The measured PR has only been considered for non- curtailed periods and hence 100% availability. The PR value for comparison becomes 80.2%. Adjustment for the second-year module degradation of 0.7% takes this to 79.6%

3.3 Wind

3.3.1 Wind speed

The wind resource for design was estimated from analysis and correlation of:

- 20-year wind speed records from the Coober Pedy Airport at 10m
- 11 months of data from the 60m wind monitoring mast installed by EDL in May 2014 close to actual WTG site (5km from airport). The monitoring mast included anemometers at 10m, 40m and 60m enabling wind shear to be estimated at the wind turbine hub height of 80m
- mesoscale modelled wind data from 3 Tier from 1981 to 2014

The results of the analysis predicted long term average wind speeds of 7.1m/s at 60m and 7.6m/s at 80m.

A SODAR wind monitoring device (Fulcrum 3D FS1) was installed 340m west of the southernmost wind turbine as the primary source of wind speed for operational performance assessment. The site is very flat and non-complex; therefore, this was viewed as appropriate and cost-effective approach rather than an 80m wind mast.

Table 3.3 shows the monthly average measured wind speeds from the SODAR and compares with the long-term projected design averages.

The FY2019 average wind speed was higher than the long term expected average and the main driver of better than design renewable contribution.

The FY19 60m and 80m wind speeds were 7.6m/s and 7.9m/s respectively, 4% higher than design at 80m.

The overall uncertainty of wind mast and SODAR measurements is around 2 to 3%. Analysis of the 60m wind and 60m SODAR data in the 13-month period of overlap prior to FY19 showed the average mast wind speed was 0.6% higher than the SODAR, which is within the measurement accuracy band.

The 80m SODAR data availability rate improved to 88% for 2019 from 81% in 2018. The limited data recovery is a limitation of SODAR technology, which is known to be increased in desert environments. It has also been observed that the SODAR error rate is increased at lower wind speeds. This is being further investigated with the SODAR supplier Fulcrum 3D. Backfilling the missing periods with nacelle wind speed measurements or other data sources reduces the SODAR gap filled average as the wind speed is typically lower in the gap periods.

Table 3.3: Design and measured wind speeds

Period	Wind speed 60m (m/s)			Wind speed 80m (m/s)				
	SODAR			SODAR[7]			SODAR (gap filled[8])	
	Design	FY 19	FY18	Design	FY19	FY18	FY19[9]	FY18
Jul	5.8	7.7	7.8	n/a	6.5	8.1	7.7	7.8
Aug	6.9	8.7	8.2	n/a	7.5	9.4	9.0	8.3
Sep	7.9	7.7	8	n/a	8.3	8.2	8.0	8.2
Oct	7.9	7.9	7.9	9.1	8.4	8.3	8.2	8.2
Nov	7.8	7.8	7	7.8	8.2	8.2	8.1	7.3
Dec	7.5	8.3	7.5	7.7	7.8	8.7	8.6	7.6
Jan	7.7	8.0	8.1	7.6	8.3	8.6	8.4	8.4
Feb	7.4	7.3	7.4	7.7	7.8	7.5	7.6	7.7
Mar	6.9	6.8	7.3	7.4	7.4	7.2	7.1	7.5
Apr	6	7.7	6.6	6.0	6.6	8.2	8.1	7
May	6.3	6.7	7	7.0	6.8	7.0	7.0	7.4
Jun	6.4	6.9	6.1	6.2	7.1	7.3	7.1	6.2
Average	**7.1**	**7.6**	**7.4**	**7.5**	**7.6**	**8.1**	**7.9**	**7.6**

3.3.2 Wind turbine performance

The wind turbine output continues to align with the modelled design performance, within the limits of the wind speed measurement accuracy.

The wind turbines were curtailed for approximately 45% of time in FY19 and were not despatched for a further 3% of time (due to wind turbine outages or control system constraints).

Significant outage events included:

- high temperature shutdowns continued to occur over summer in December and January, reducing overall performance as expected. The wind turbines are designed to de-rate from 40°C and shutdown at 42°C (measured outside the nacelle). This was allowed for in the design wind energy yield assessment, but the impact is spread across the year in target performance calculations

Wind turbine output continues to meet expectation. The assessment is limited to non-curtailed operating periods (approximately 52% of the time). Applying the measured gap filled SODAR wind speed through a simple wind turbine performance model with average design losses, shows slight variance to design, but within the wind speed measurement error.

The estimated potential wind generation noted in Table 3.1 was generated by processing wind speed in 10-minute periods through the performance model to estimate potential generation in curtailed periods.

[7] The average availability of SODAR data at 60m and 80m was 93% and 87% respectively for FY19. The nature of the SODAR measuring process means many data points are filtered out when not meeting minimum quality criteria. Desert environments are known to be challenging for SODAR.

[8] The gaps in data have been filled using the average of the four nacelle mounted anemometers on the 2 wind turbines, or if also unavailable, wind output projected from other SODAR heights

[9] The gap filled average is lower because the filled periods have lower average windspeed. The SODAR data error rate is noticeably higher at lower wind speeds.

For this process the model has been calibrated with measured performance in non-curtailed periods to best represent the generation received at the diesel power station HV switchboard.

3.4 Diesel station

All eight-existing diesel fired generating units have been retained to ensure that the station is capable of meeting load requirements. This is because there are occasions when there is no wind or solar output, meaning full customer load must be met by diesel-fired generation.

The average diesel load and number of diesels on-line has reduced significantly since commencement of operations of the Project as shown in Table 3.4.

For FY2019, the Project has run on a “zero-diesel” basis for 52% of time.

The average engine load has decreased from around 75% to 53% of a nominal 530kW rated capacity. The engines also spend a lot of time running at minimum load, which is currently set at 30% of rated capacity in line with manufacturers recommendation. Running at lower average load means the average heat rate (fuel efficiency) has deteriorated by around 3.5%, which is in line with expectations.

There has been no observable maintenance impact of running the engines at lower loads, but it is too early to assess any long-term impacts. This will continue to be monitored over future years. The engines are approximately 15 years old, so are no longer covered by the manufacturer’s warranty. There are still times when there is no wind or solar and the load is supplied totally by diesel. Hence, all diesel sets are still required and will be maintained into the future. With significantly reduced overall operating hours, the time between major overhauls will be extended.

Table 3.4: Average diesel engine load pre- and post-hybrid

	Year	**Engine hours**	**Average engine load**[10] (kW)	Percentage of rated load (%)	Average fuel efficiency (/kWh)
Pre-hybridisation	FY15	30,188	392.9	74%	0.260
	FY16	32,058	374.7	71%	0.261
	FY17	31,190	392.3	74%	0.260
	Average	**31,145**	**386.6**	**73%**	**0.260**
Post-hybridisation	FY18	15,577	268.4	51%	0.269
	FY19	10,759	280.4	53%	0.269

3.5 Enablers and hybrid control system

The suite of enabling technologies and overarching control system continue to perform well and have been very effective in managing renewable variability while maintaining power quality and reliability. The enablers include the dynamic resistor (DR), diesel UPS (DUPS) and battery energy storage system (BESS).

Some issues have arisen impacting rating and availability of some components (as described in the following sections), however, this has had minimal impact on overall RE% achieved due to the

[10] Gross at generator terminals

resilience of the overall design and ability to keep operating with components out of service or at reduced capacity.

3.5.1 Dynamic resistor

The DR's have experienced a gradual reduction in their available capacity over the course of the year, which was identified during routine observations of the system. This varies per unit but is up to 30% on certain units.

As a result, EDL has prioritised the replacement of the units to avoid further deterioration that may begin to impact system performance. After the issue was identified, the condition of the resistive heating elements and the associated electronic phase angle controllers were investigated further. A DR resistor bank has been removed from site for further investigation.

The issues have not detrimentally affected performance as demand to date has generally been much lower than the peak system design demand of around 3MW. However, the aim is to bring all DR units back to full capacity to ensure full design capacity again.

3.5.2 Diesel UPS

The DUPS have been performing well. One or two DUPS are on in synchronous generator mode most of the time. Engagement of the clutch and starting of the diesel engine to provide real power occurs infrequently, but like any stand-by generator, has high reliability when called upon. The DUPS undergo a test run for one hour every month.

The DUPS phase imbalance trips noted in the FY18 report have been resolved by Coober Pedy District Council correcting the phase imbalance within the network.

3.5.3 Battery energy storage system

The power delivery and response of the BESS continues to meet expectations, with the BESS demonstrating it can provide rapid response to sudden load changes and rapidly switch from charge to discharge.

- The HVAC availability and humidity control issues noted in the FY18 report have largely been resolved during 2019. Availability was noticeably affected by the issue prior to it being corrected, but has subsequently improved. The original equipment manufacturer (OEM) has installed an external humidifying system, with a control system that maintains the humidity within the required range in the BESS container. The system is working extremely well, and BESS availability is much improved as a result. Figures 3.7 & 3.8 below show the performance before and after the humidifier was installed.
- There were several minor software issues during the period, which were resolved with the assistance of the OEM
- The BESS energy capacity has shown minimal degradation to date and is within expectation.
- The single round trip cycle efficiency exceeds the design requirement of 85%, however the average round trip efficiency across the year has been below 65% due to standing and auxiliary losses when the battery sits on standby, which is for a large part of the year. This will be further investigated
- An electrical contactor failed in early August 2019 (outside FY19)

The Project can still achieve "zero diesel operations" (ZDO) when the BESS is unavailable, however, the overall control system is restricted in its ability to maintain ZDO in such circumstances. This is because if the discharge capacity of the BESS is not available to provide "Operating Reserve". Even if the BESS is never called upon to discharge, if unavailable, it must be replaced by DR spill or on-line diesel generator capacity.

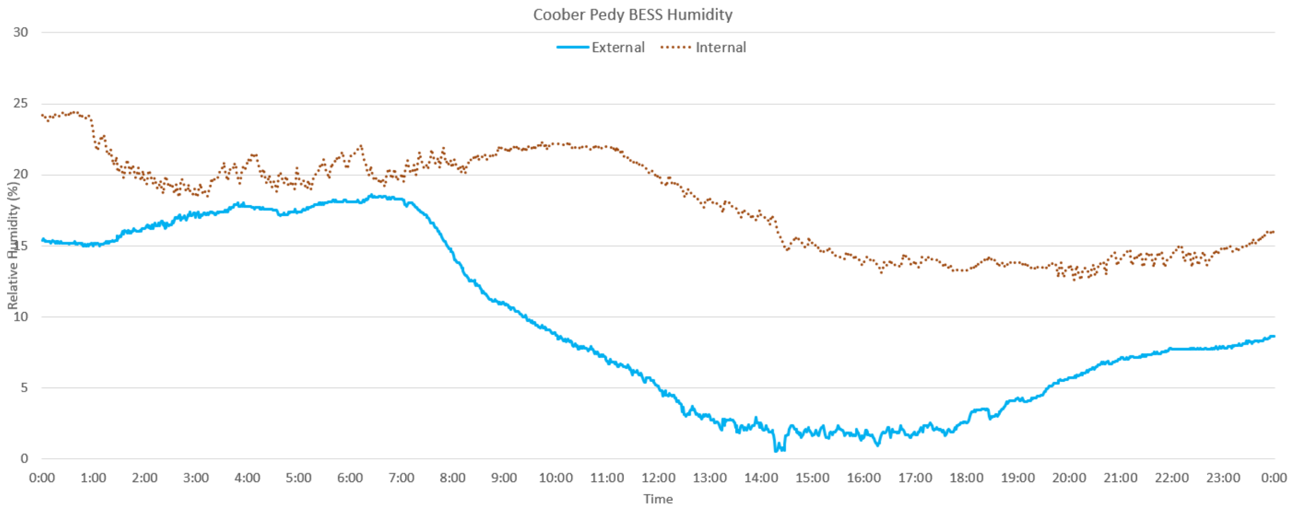

Figure 3.7: BESS humidity control prior to humidifier installation

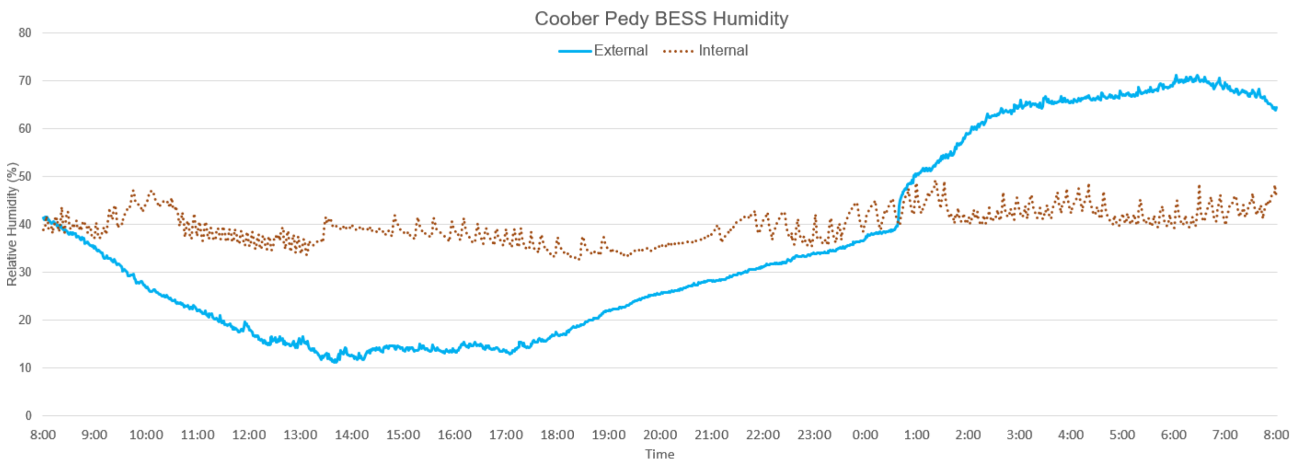

Figure 3.8: BESS humidity control after humidifier installation

3.5.4 Hybrid control system

The hybrid control system monitors the entire Project and sends power set point commands to the diesel, wind, solar and enabling technology sub-controllers. It continues to demonstrate its ability to manage all situations encountered to date including solar, wind and customer feeder trips at high load.

The system was tuned during the settling period to achieve very stable and robust operation. The system will generally keep operating with one or more components out of service, but with a reduced renewable energy penetration.

No changes have yet been made to the control logic during the year, but this is subject to ongoing review to assess if further fine tuning can increase the overall RE energy utilisation without unduly increasing operational risk.

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3.6 Overall system performance

The Project commenced commercial operations on 1 July 2017. The renewable penetration ramped up over the initial three-month settling period (July–September 2017).

Table 3.5 shows the monthly performance of the Project for FY19.

While performance has exceeded expectations, there is still scope for some further improvement.

Areas for improvement include:

- improving the availability of all system components
- fine tuning of control set points to turn diesel generators off more quickly and make increased use of BESS capacity
- considering the potential to utilise the spill in the future via energy storage and smart load management (around 44% of total renewable generation was spilled/curtailed in FY19)

Table 3.5: Coober Pedy Hybrid Renewable Project monthly performance

Period	Potential		Actual Generated		Total		Resistor Spill	System Losses	RE to Customer	Diesel to Customer	Total Load	RE% of Customer Load	Hours of ZDO
	Solar	Wind	Solar	Wind	Potential RE	Generated RE							
	MWh	**MWh**	**MWh**	**MWh**	**MWh**	**MWh**	**MWh**	**MWh**	**MWh**	**MWh**	**MWh**	**%**	**Hrs**
Jul-18	198	1315	139	1128	1513	1267	384	89	794	266	1060	75%	355
Aug-18	203	1724	128	1427	1926	1555	645	98	812	159	971	84%	464
Sep-18	218	1388	155	1044	1607	1199	442	90	667	170	837	80%	382
Oct-18	205	1417	155	1084	1622	1238	431	103	705	157	862	82%	429
Nov-18	211	1315	151	893	1526	1044	251	99	693	171	864	80%	415
Dec-18	223	1491	158	995	1714	1153	286	107	760	262	1022	74%	437
Jan-19	216	1463	181	924	1679	1105	231	95	778	420	1198	65%	402
Feb-19	221	1087	182	801	1309	983	191	95	697	237	933	75%	317
Mar-19	225	1049	184	838	1274	1022	203	99	720	297	1017	71%	299
Apr-19	208	1295	122	1077	1502	1199	402	109	689	162	851	81%	436
May-19	199	1142	127	848	1341	974	229	88	657	224	881	75%	302
Jun-19	177	1252	144	907	1429	1051	202	78	771	295	1066	72%	284
TOTAL	**2504**	**15939**	**1825**	**11965**	**18444**	**13791**	**3897**	**1150**	**8744**	**2819**	**11563**	**75.6%**	**4521**

3.6.1 Daily modelled vs actual performance

Figure 3.8 below shows the daily system performance during June 2019 and compares it with a simplified theoretical target model that processes load, wind speed and solar irradiance data at 10-minute intervals to estimate the overall renewable contribution that could be achieved.

The model simplifies the actual operation of the control system applying average allowances for equipment availability, turbine wake losses, and other operational constraints over the whole year.

As a result, modelled performance does not align with actual performance daily, but more accurately aligns with actual performance over longer term periods. Daily performance charts for each month of 2019 are shown in Appendix A.

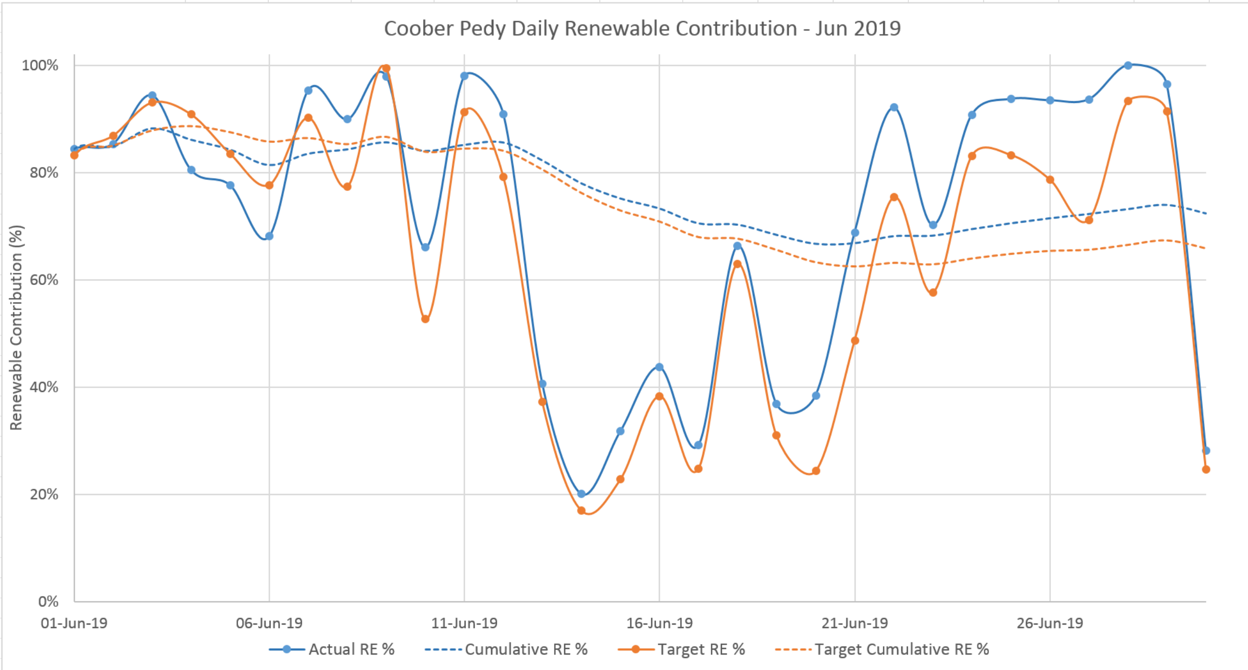


Figure 3.8: Daily RE % contribution for June 2019

3.6.2 Component availability

The expected and actual reliability of the system components are shown in table 3.6 below.

Table 3.6: Project system component availability

Component	Expected availability	Actual availability
Solar PV	95%	~91%
Wind turbines	95%	99.6% (WTG equipment) >97% (overall, including temperature derating)
BESS	95%	87.4% Refer to section 3.5.3 for further details.
DUPS	95%	Direct measurement not possible due to system configuration
Dynamic resistors	95%	Refer section 3.5.1.
Control system	100%	Very high

Specific comments on each component have been made earlier in the report. From an overall system perspective, while the overall reliability of the system has been within expectations, the failures have been significant, and considerable effort has gone into promptly rectifying these. The design of the Coober Pedy system is such that while individual system components do not necessarily have redundancy, the overall blend of different technologies nominally provides effective redundancy at system level.

The technology employed at Coober Pedy is different to that at our other remote sites. Despite the early issues to date, EDL is confident that a similar maintenance approach to that used on other remote sites will apply to Coober Pedy and ensure a high level of availability. This includes appropriate spares strategies, active engagement with suppliers, embedment of service level agreements where appropriate and upskilling of staff.

Due to the early failures, EDL is monitoring the system closely to ensure that other items of a similar nature are addressed and mitigated in the future. EDL is satisfied that the specific issues experience to date have been satisfactorily resolved. As a result, it is not currently expected that the O&M costs associated with the project will exceed our initial projections.

3.6.3 Management of contingency events and system reliability

Contingency events such as a load feeder trip, diesel generator trip or wind or solar feeder trip are extreme variability events. The system has proved very resilient to such events which continued to occur in FY19 with no unexpected outages or performance deviations. The DUPs is particularly important to this resilience. The frequency of engagement is highly variable and dependant on RE variability, but on average the DUPS engage around 1.5 times per day.

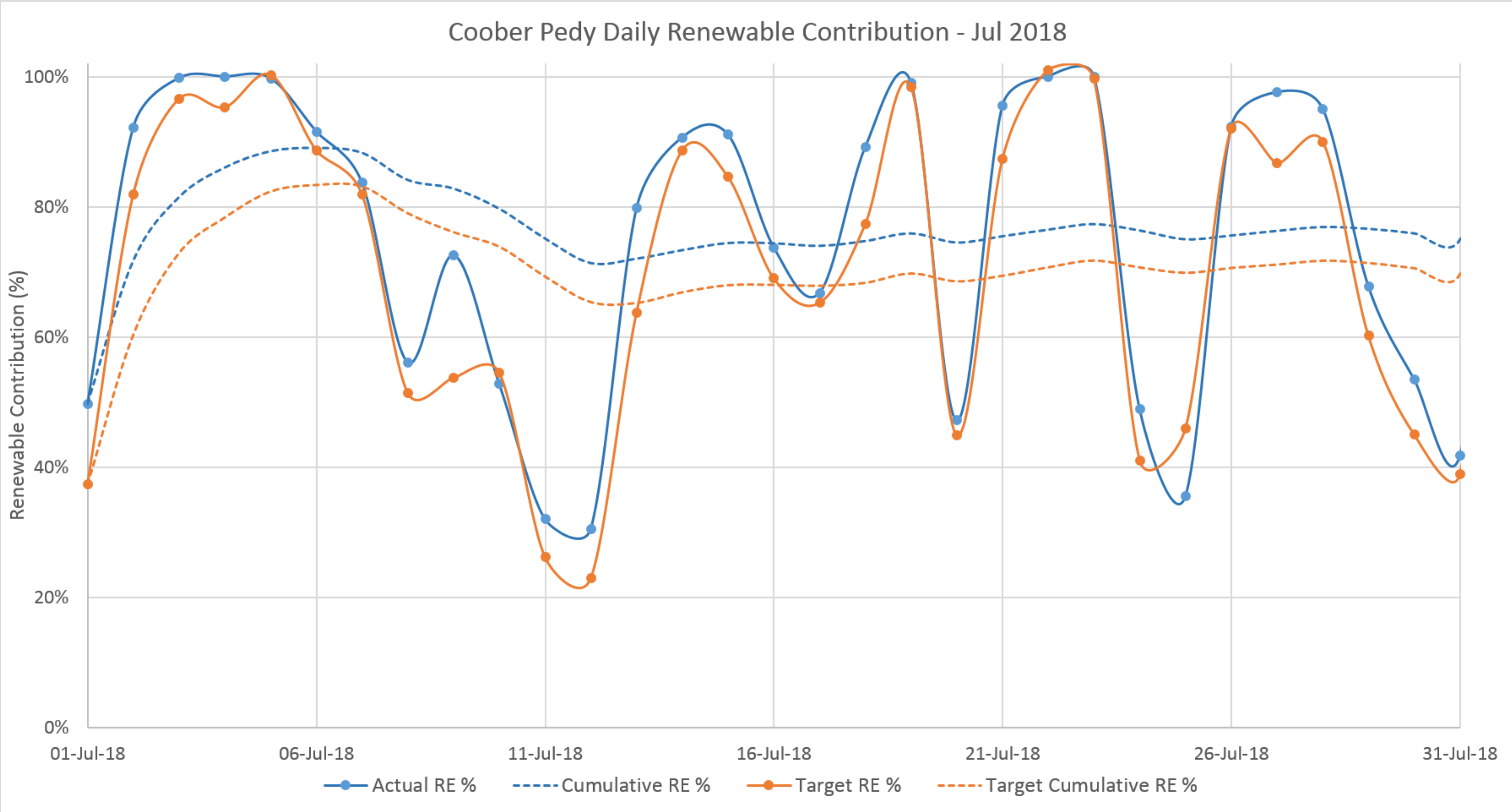
For the second year of operation, the Project has continued to provide better power reliability than the diesel-only station.

Table 3.7 shows the reliability of the Coober Pedy Power Station over the past five financial years. For the first full year of operation of the Project, both the number and the duration of unplanned outages decreased. Furthermore, three of the four unplanned outages in FY18 occurred during the settling period. The FY19 performance has been similar to FY18.

Table 3.7: Coober Pedy Power Station unplanned outage history

	Year	Unplanned outages (Occurrences)	Duration (hours)
Pre-hybridisation	FY15	4	3.5
	FY16	5	1.1
	FY17	4	4.2
	Average	**4.3**	**2.9**
Post-hybridisation	FY18	4	0.47
	FY19	2	0.52

Appendix A - Daily RE Performance by Month



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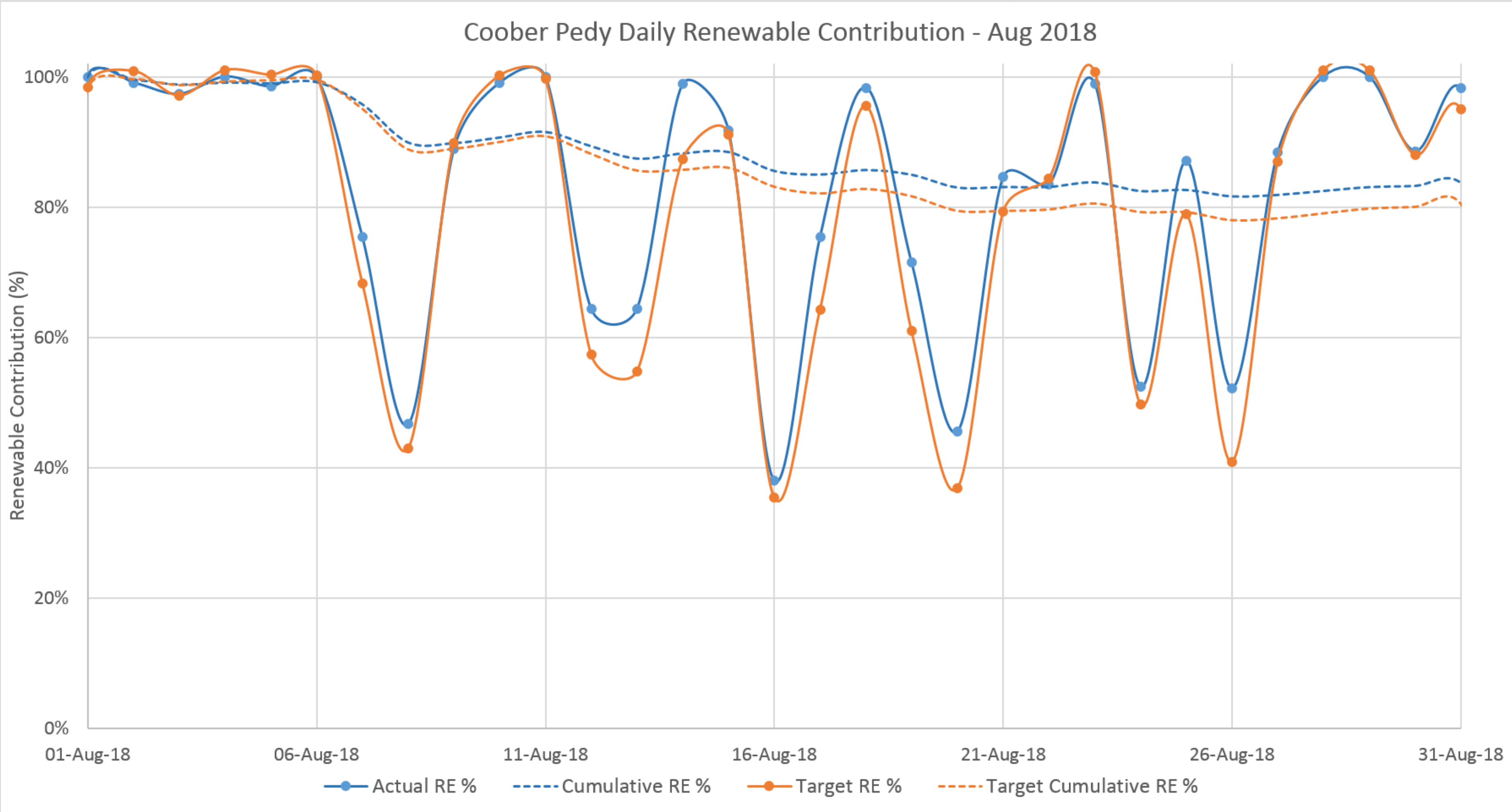
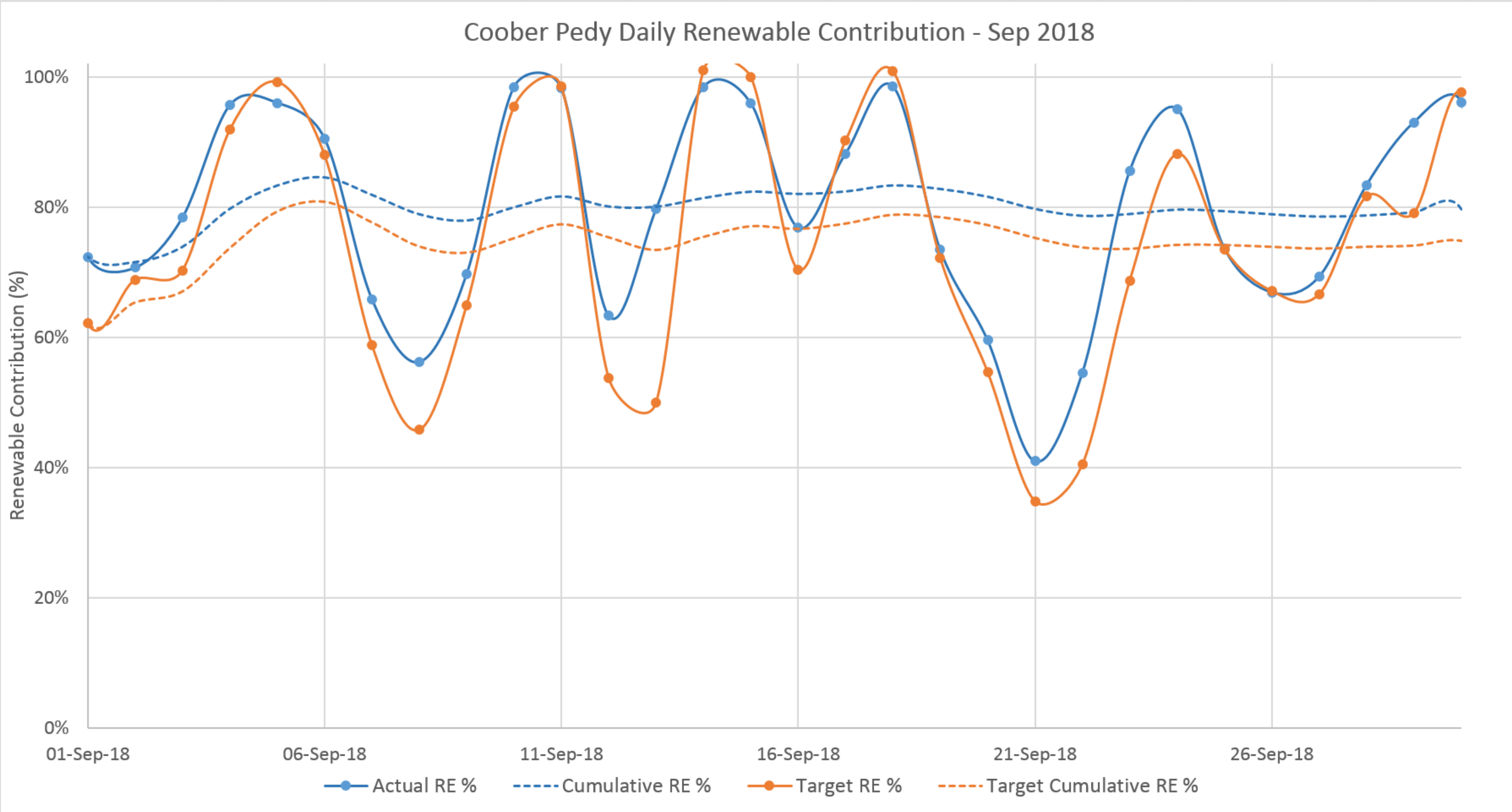
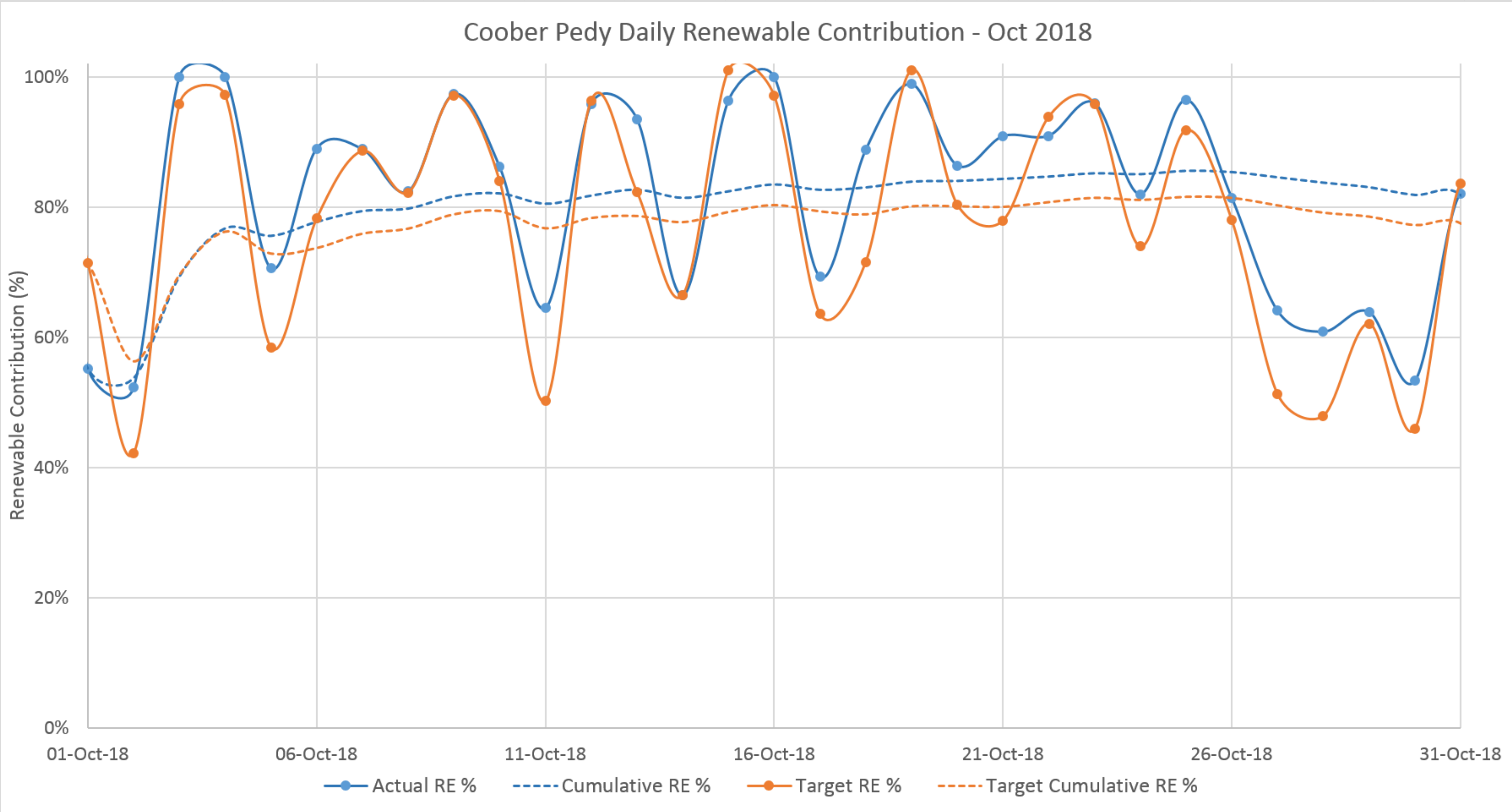

Coober Pedy Daily Renewable Contribution - Aug 2018
Renewable Contribution (%)
100%
80%
60%
40%
20%
0%
01-Aug-18
06-Aug-18
11-Aug-18
16-Aug-18
21-Aug-18
26-Aug-18
31-Aug-18
Actual RE %
Cumulative RE %
Target RE %
Target Cumulative RE %


Coober Pedy Daily Renewable Contribution - Sep 2018
Renewable Contribution (%)
100%
80%
60%
40%
20%
0%
01-Sep-18
06-Sep-18
11-Sep-18
16-Sep-18
21-Sep-18
26-Sep-18
Actual RE %
Cumulative RE %
Target RE %
Target Cumulative RE %



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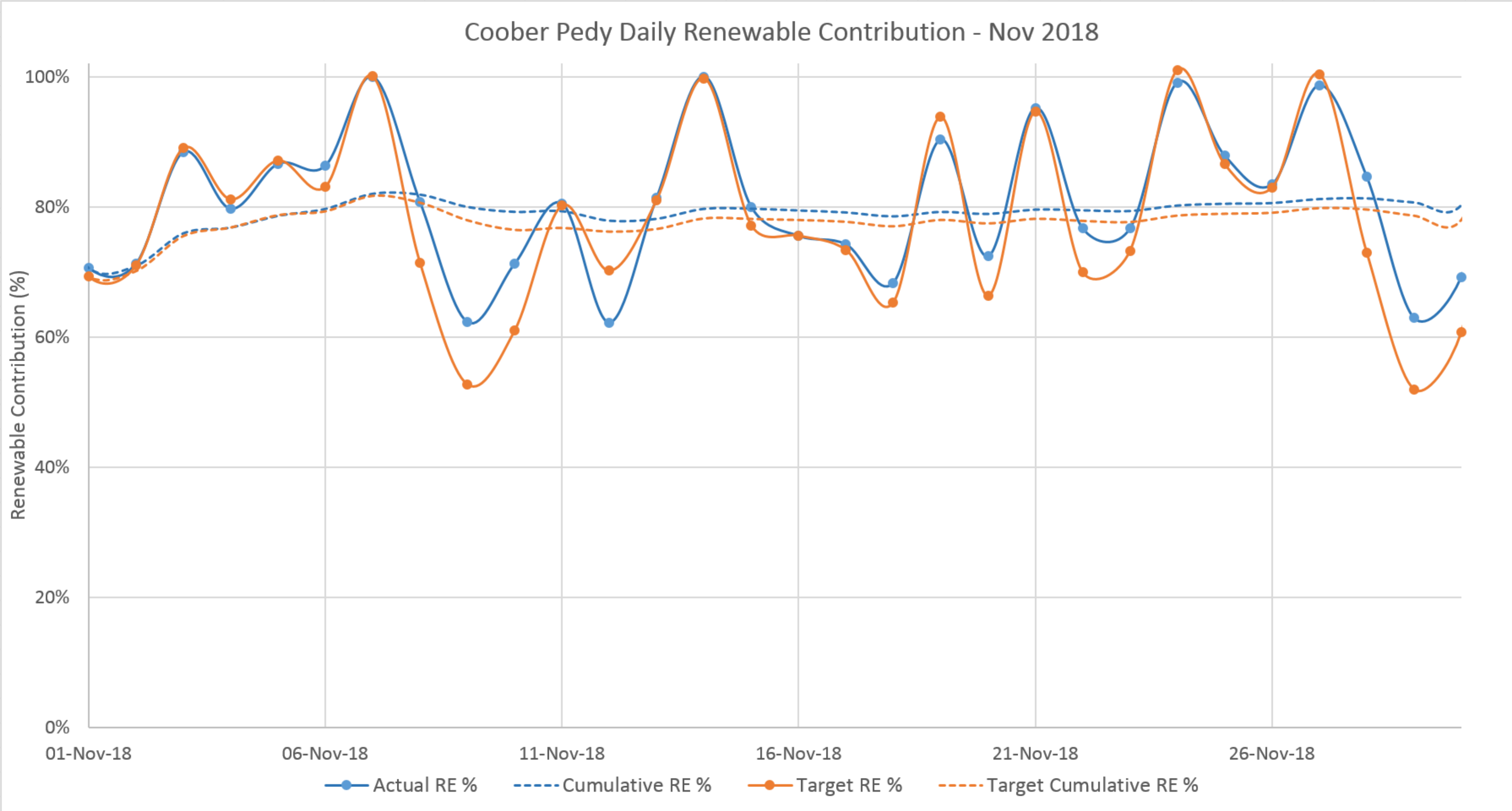
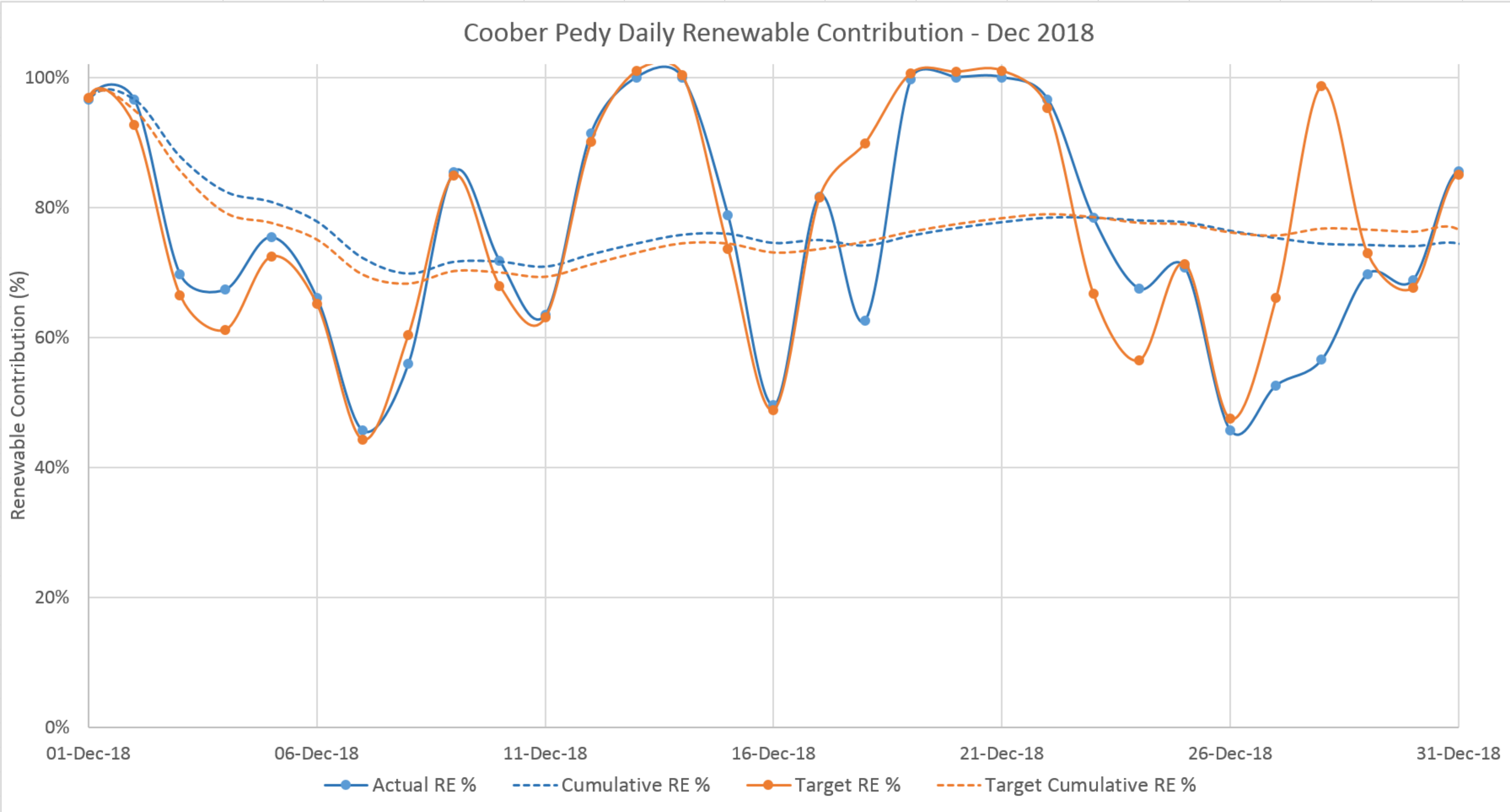
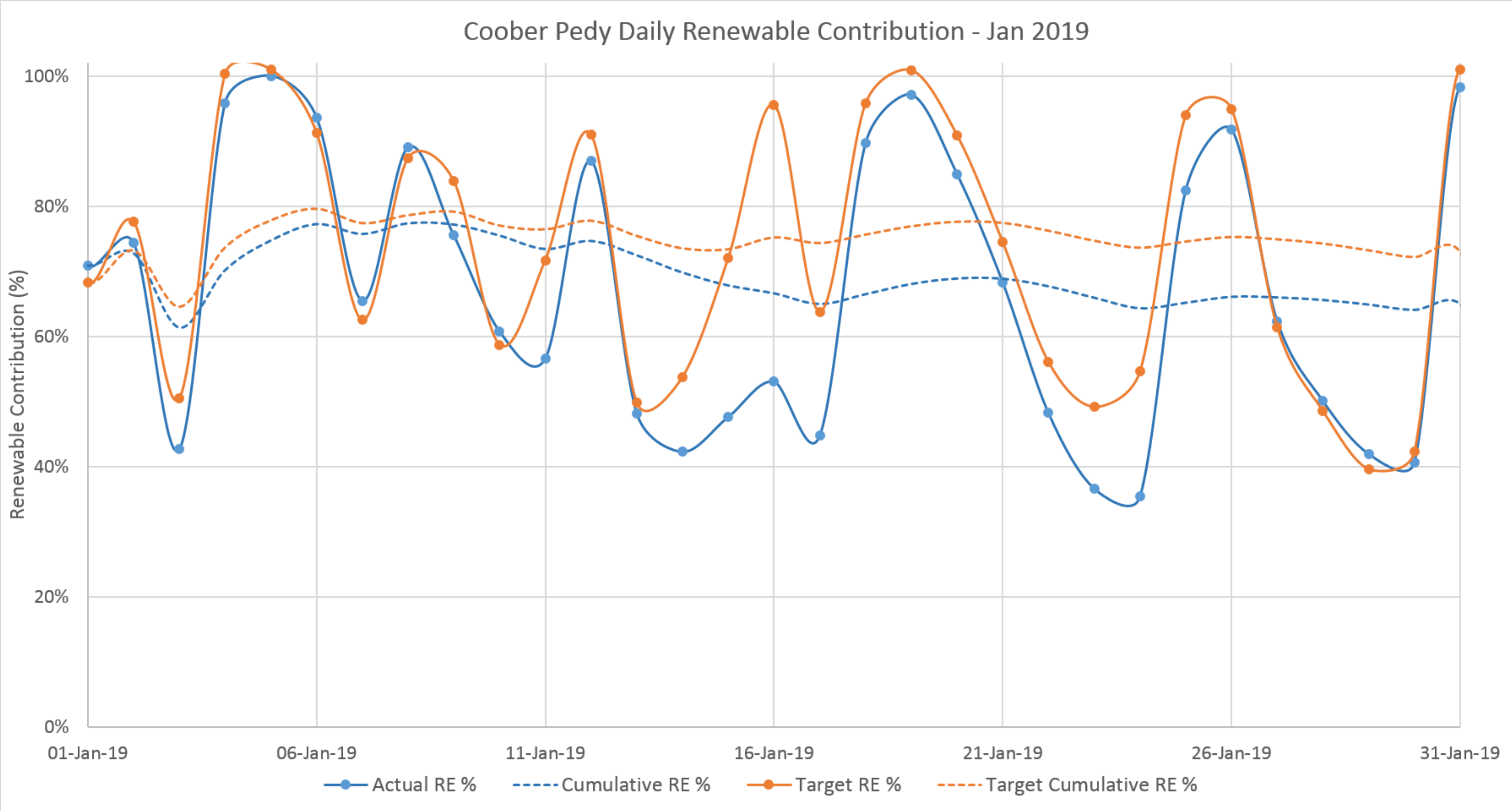

Coober Pedy Daily Renewable Contribution - Nov 2018
Renewable Contribution (%)
100%
80%
60%
40%
20%
0%
01-Nov-18
06-Nov-18
11-Nov-18
16-Nov-18
21-Nov-18
26-Nov-18
Actual RE %
Cumulative RE %
Target RE %
Target Cumulative RE %


Coober Pedy Daily Renewable Contribution - Dec 2018
Renewable Contribution (%)
100%
80%
60%
40%
20%
0%
01-Dec-18
06-Dec-18
11-Dec-18
16-Dec-18
21-Dec-18
26-Dec-18
31-Dec-18
Actual RE %
Cumulative RE %
Target RE %
Target Cumulative RE %



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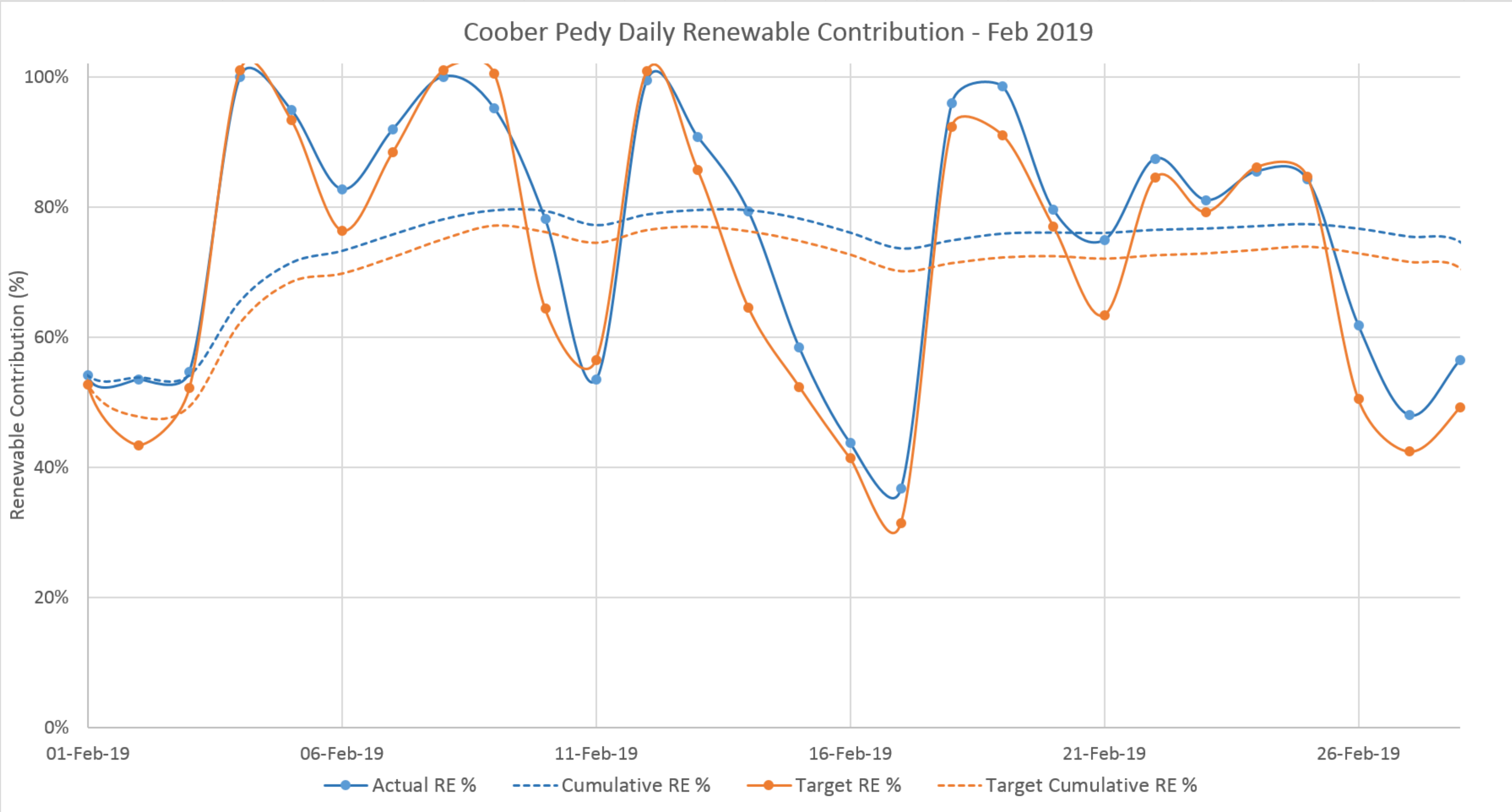
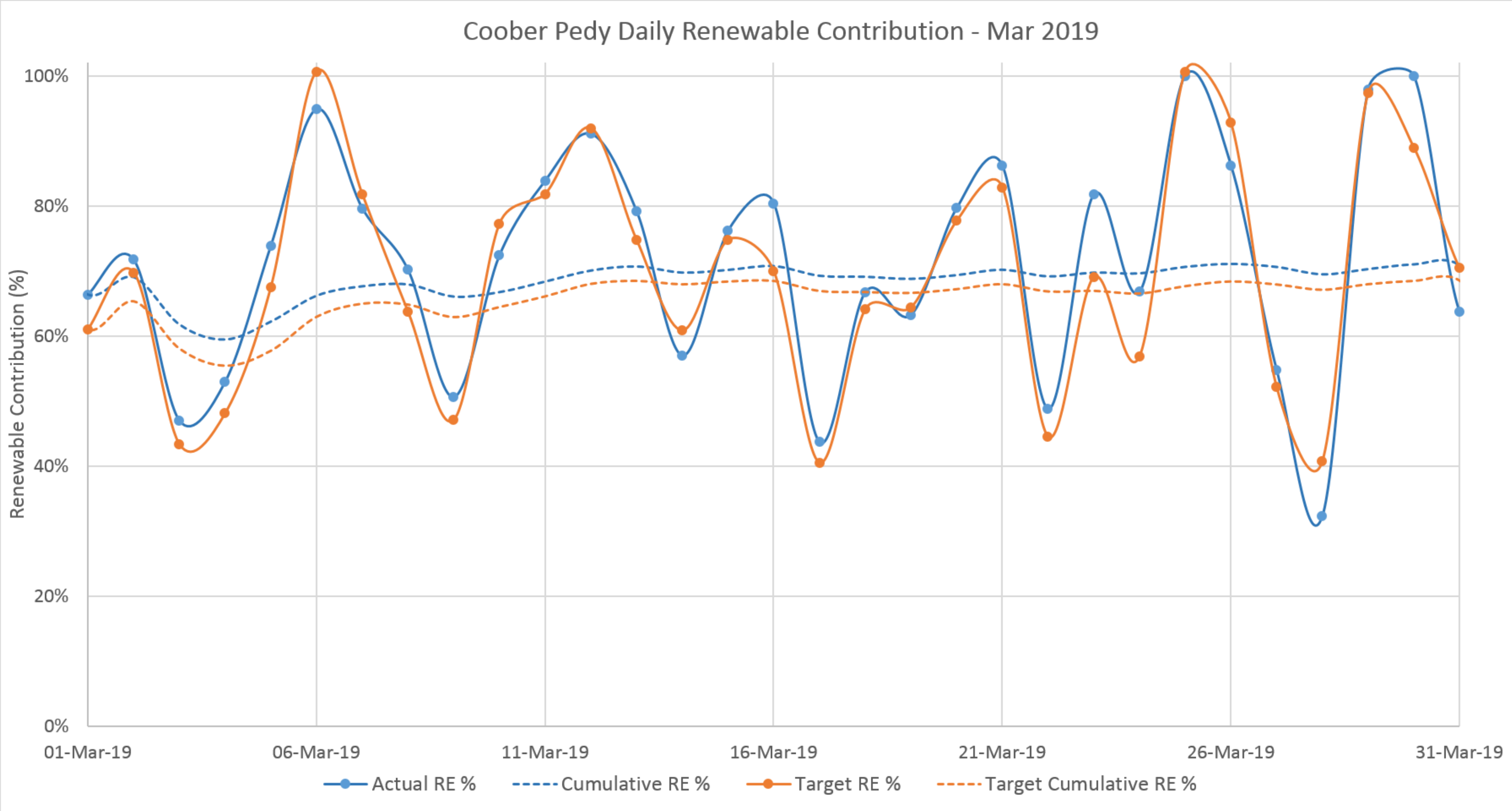
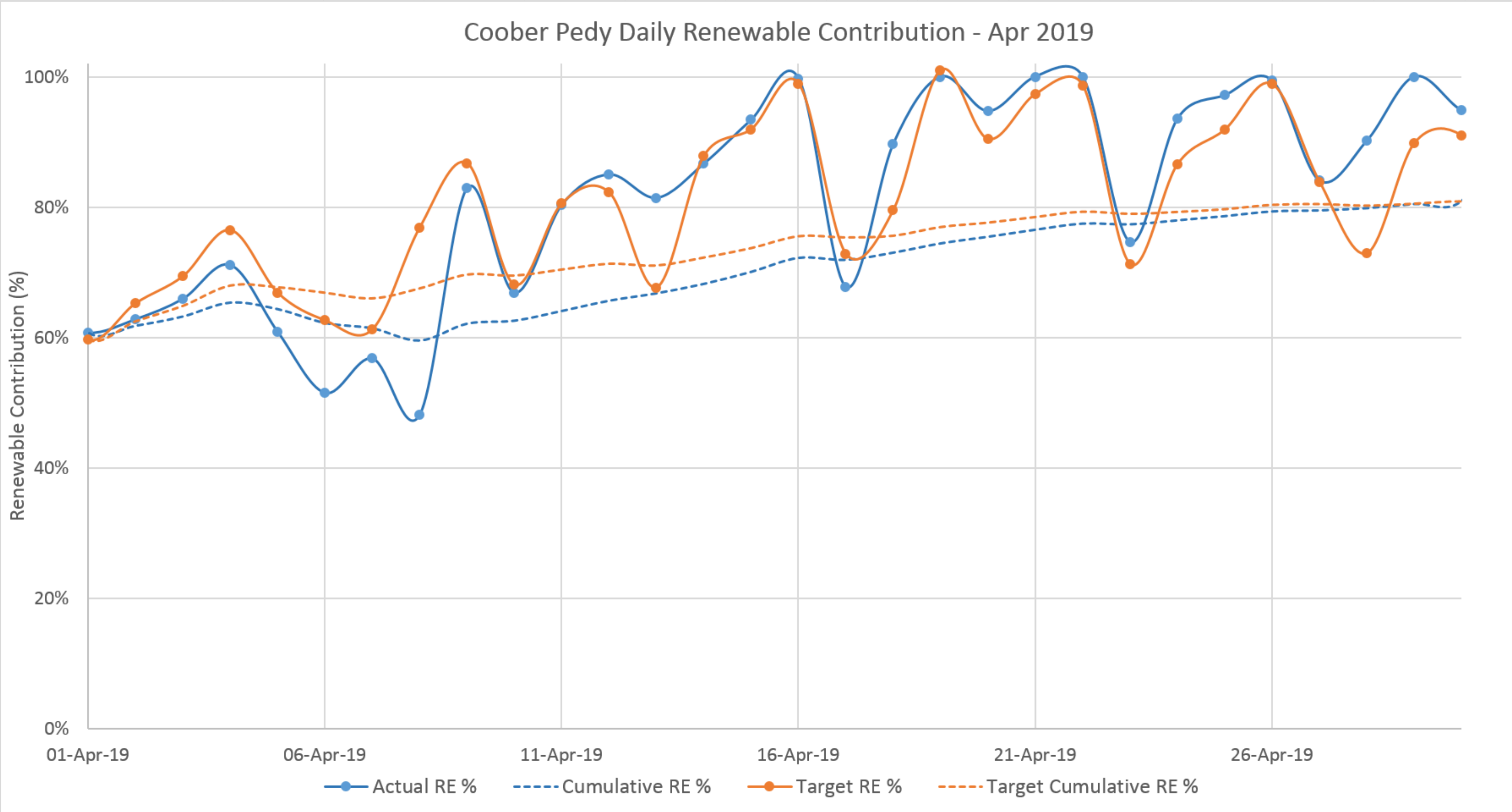
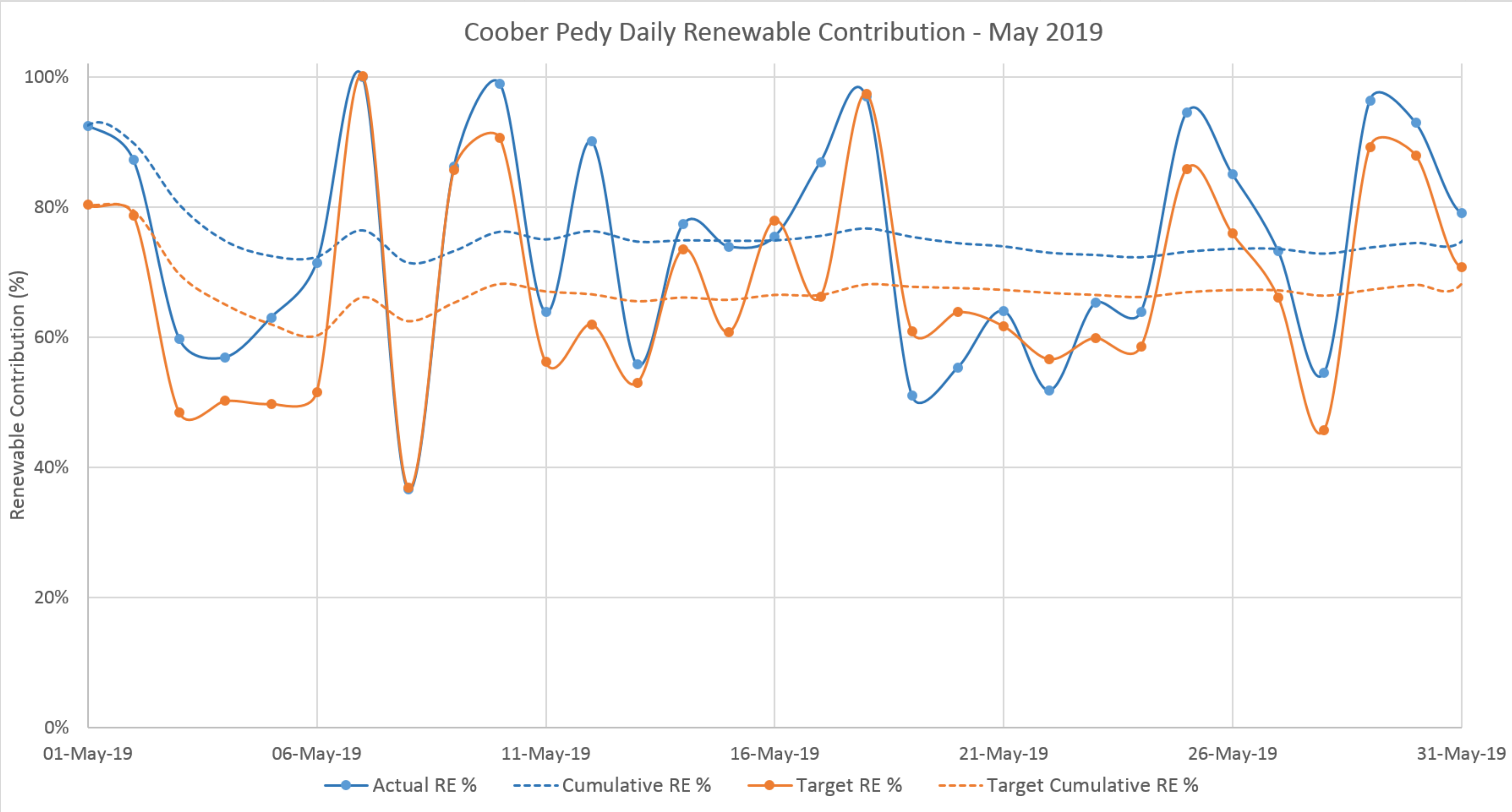

Coober Pedy Daily Renewable Contribution - Feb 2019
Renewable Contribution (%)
100%
80%
60%
40%
20%
0%
01-Feb-19
06-Feb-19
11-Feb-19
16-Feb-19
21-Feb-19
26-Feb-19
Actual RE %
Cumulative RE %
Target RE %
Target Cumulative RE %

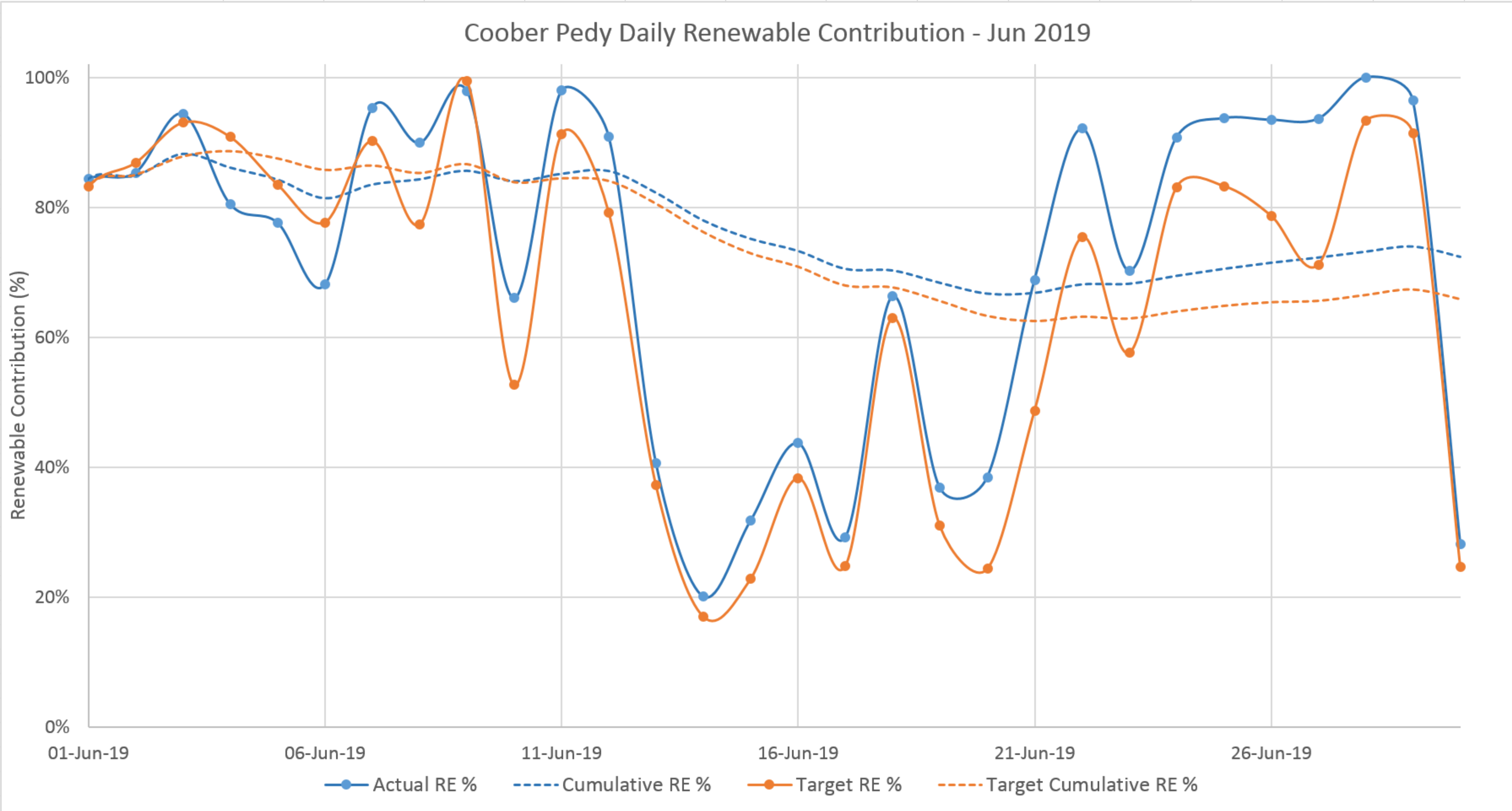


A world of
new energy



Coober Pedy Daily Renewable Contribution - Apr 2019
Renewable Contribution (%)
100%
80%
60%
40%
20%
0%
01-Apr-19
06-Apr-19
11-Apr-19
16-Apr-19
21-Apr-19
26-Apr-19
Actual RE %
Cumulative RE %
Target RE %
Target Cumulative RE %


Coober Pedy Daily Renewable Contribution - May 2019
Renewable Contribution (%)
100%
80%
60%
40%
20%
0%
01-May-19
06-May-19
11-May-19
16-May-19
21-May-19
26-May-19
31-May-19
Actual RE %
Cumulative RE %
Target RE %
Target Cumulative RE %


Coober Pedy Daily Renewable Contribution - Jun 2019
Renewable Contribution (%)
100%
80%
60%
40%
20%
0%
01-Jun-19
06-Jun-19
11-Jun-19
16-Jun-19
21-Jun-19
26-Jun-19
Actual RE %
Cumulative RE %
Target RE %
Target Cumulative RE %